PRELIMINARY STUDIES ON THE DISTRIBUTION OF CHAROPHYTES IN SAUDI ARABIA

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ABSTRACT - Identification of Charophytes collected from various regions of Saudi Arabia together with detailed bio-ecological data for each taxon was made. Seven *Chara* (*C. aspera, C. fibrosa, C. globularis, C. setosa, C. vulgaris f. contraria, C. vulgaris* var. *longibracteata, C. zeylanica* var. *diaphana f. oerstediana*) and one *Nitella* are recorded for the first time from Saudi Arabia. The waters were highly calcareous with high Mg^{++}: Ca^{++} ratio and high concentration of HCO_3^- ($\bar{x}$ = 215 mg.l^{-1}). Chromosome numbers of most of the taxa are determined.

RÉSUMÉ - La détermination des Charophytes récoltés dans différentes régions d'Arabie Séoudite est présentée avec des données bio-écologiques détaillées pour chaque taxon. Sept espèces de *Chara* (*C. aspera, C. fibrosa, C. globularis, C. setosa, C. vulgaris* f. *contraria, C. vulgaris* var. *longibracteata, C. zeylanica* var. *diaphana* f. *oerstediana*) et une Nitelle sont signalées pour la première fois en Arabie Séoudite. Les eaux sont très calcaires avec un rapport élevé de Mg^{++}: Ca^{++} et une forte concentration en HCO_3^- ($\bar{x}$ = 215mg.l^{-1}). Les nombres chromosomiques de la plupart des taxons sont fixés (traduit par la rédaction).

KEY WORDS : systematic enumeration, *Chara, Nitella,* distribution, Saudi Arabia.

INTRODUCTION

Little or no effort has been devoted to the study of Charophytes and their distribution in Saudi Arabia. However, Proctor (1980) stated about a clone x-575 (n = 14) as a representative *Chara* range in Saudi Arabia. Khoja *et al.* (1984) have recorded the occurrence of *Chara* for the first time in a stream at Al-Bahah in the south-western of the Kingdom. Recently Whitton *et al.* (1986) reported *Chara vulgaris* L. from two sites in the Asir mountains. The present work is undertaken to assess the range of Charophytes in various regions of Saudi Arabia in general and that of Al-Hassa in particular. All taxa have been identified following in general the format of

modern floras such as: Imahori (1954), Pal *et al.* (1962), Wood & Imahori (1964-1965), Corillion & Guerlesquin (1972), Wood (1972), Corillion (1975). It will cover fundamental information whenever possible on the geographical distribution and some physico-chemical characteristics of water.

ENVIRONMENTAL BACKGROUND

Saudi Arabia is characterised by a hot climate. The average annual temperature is about 35.0° in summer and 25.0°C in winter, but there are wide variations. For example, inland temperatures range from below zero at night to a maximum of 50.0°C during summer. Records of water temperature of study area are not included, because of the varying times of day; the values ranged from 20.0°C at Al-Bahah to 30.0°C at Al-Hassa and Qasseem. Rainfall in the upper two thirds of the Kingdom is scanty, unpredictable and irregular. The average annual rainfall varies from 40.0mm to 90.0mm which is unsufficient to meet the needs of agriculture.However, it is not uncommon to find oases and wadi channels scattered throughout the country where springs and shallow ground water are available. For example, there are about 162 artesian springs in Al-Hassa oases and the land under cultivation is about 8,000ha. The irrigation water is saline (Hussain, 1978). The climate in south-western Saudi Arabia is completely different. The annual rainfall exceeds 300mm and in some areas it is as much as 700mm (for references see Vesey-Fitzgerald, 1955; Dreaver *et al.*, 1981; Brooks & Mandil, 1983). Different stream systems occur in the region with conspicuous algal growth (Whitton *et al.*, 1986).

MATERIAL AND METHODS

Samples were collected from natural habitats and included for all of the species is a map showing its distribution in the Kingdom (Fig. 1). Details of habitats and the ecology of individual taxon is dealt with after each description in the systematic enumeration. The material collected was preserved in 3% formalin for identification purpose. The rest of the material was fixed in the fixing solution of 3 parts of absolute alcohol and 1 part of acetic acid. Encrusted species were decalcified before preservation and fixation with 10% nitric acid until the bubbling ceases. Plants were washed free of acid with distilled water. The modified iron alum acetocarmine method of Godward (1966) was adapted for cytological investigation and chromosome counts were made from the treated antheridial filaments and young branchlets at metaphase and anaphase stages. Temperature and pH were determined in the field for each site of collection. Cations and anions were analysed following the methods described by Whitton *et al.* (1986), using a SP 9 Pye Unicam atomic absorption spectroscopy and a Hach (DR-EL/2) portable spectrophotometer. Titrimetric analysis of total alkalinity (as $CaCO_3$),

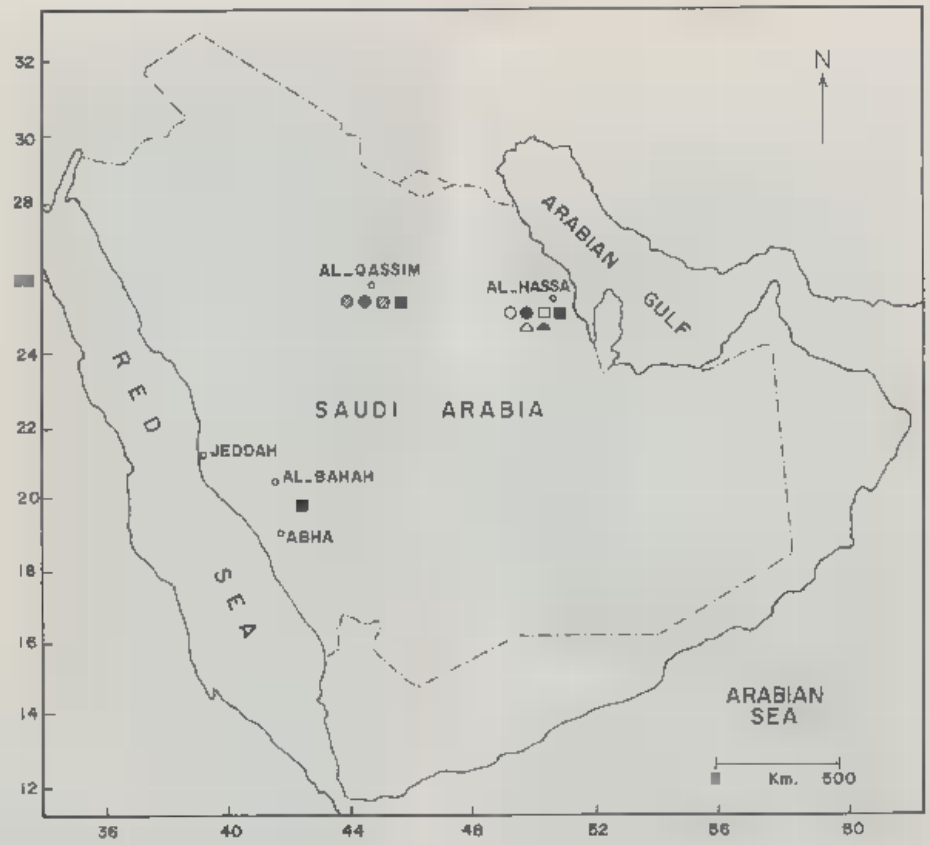

Fig. 1 - Map of Saudi Arabia showing the distribution of various species recorded: o *Chara aspera* Deth. ex Willd., ⊙ *C. fibrosa* Ag. ex Bruz., em. R.D.W., • *C. globularis* Thuill., em. R.D.W., □ *C. setosa* Klein ex Wild., ▨ *C. vulgaris f. contraria* (A. Br. ex Kütz., pro parte) R.D.W., ▪ *C. vulgaris* var. *longibracteata* (Kütz. in Reich.) H. et J. Groves, Δ *C. zeylanica* var. *diaphana f. oerstediana* (A. Br.) R.D.W., ▲ *Nitella* sp.

HCO^{-}_{3} and CO^{--}_{3} were also made. All tests were repeated twice and additional tests were performed whenever, any anomalous results were obtained. The materials were photographed by a Wild stereoscopic photomicroscope.

SYSTEMATIC ENUMERATION

Chara aspera Deth. ex Willd. (Figs. 2 et 3)

Plants dioecious, 20cm high, slightly encrusted. Axes 450μm in diameter; cortex triplostichous, tylacanthous. Spine-cells solitary, long or short and rarely geminate, enbulging at the bottom and tapering towards apex. Stipulodes diplostephanae, both whorls almost equally developed. Branchlets

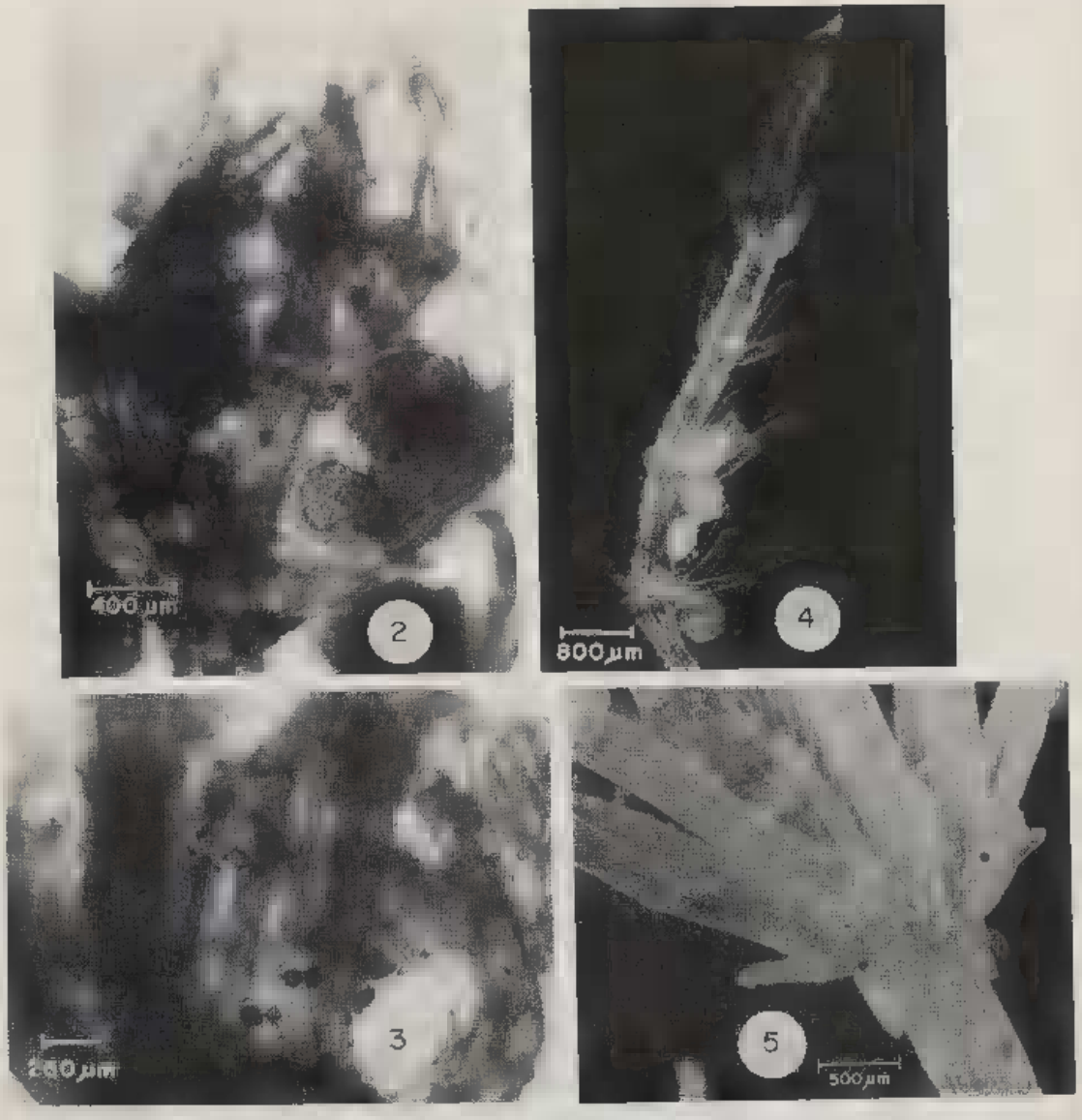

Fig. 2 et 3 - *C. aspera* Deth. ex Willd., Fig. 2. Upper part of plant, showing cortication, stipulodes, antheridium and pattern of shield cell. Fig. 3. Main axis, showing geminate spine-cells. - Fig. 4. *C. vulgaris f. contraria* (A. Br. ex Kütz., proparte) R.D.W.,showing branchlet with conjoined gametangia, ecorticated upper most segments and reduced end cell. - Fig. 5. *C. vulgaris* var. *longibracteata* (Kütz. in Reich.) H. et J. Groves, showing indispensable variations single, double, irregular and short stipulodes.

6-8 in a whorl, spreading incurved, diplostichous; segments 4-6 of which the ultimate 1-2 are ecorticated. Bract cells 5-6 in number, lateral and anterior

longer than oogonium. Antheridium and oogonium solitary at the lowest 3-4 nodes, oogonium 680μm long and antheridium 450μm in diameter.

Habitat: In a slow-moving water of drainage ditch about 0.5m deep; muddy bottom. The robust plant was found in the community of *C. vulgaris*, where the latter was dominant flora, giving an impression of underwater meadows. When the plants were pluck out of their habitat, the extensive rhizoidal anchoring system remained behind and a few entire rhizobenthos found along the bunch. *C. aspera* was found at one of such hard to access site with quick sand at the bottom. The plant had no bulbils on the rhizoids. pH 7.5; $CaCO_3$ 620 ppm; Al-Hassa; October, 1986.

Chromosome number: n = 14

Remarks: Good agreement exists between the material and that described by Pal *et al.* (1962).

***Chara fibrosa* Ag. ex Bruz., em. R.D.W.**

Plants monoecious, 6-8cm high, encrusted. Axes 450μm in diameter; cortex diplostichous. Spine-cells solitary, up to 600μm long. Stipulodes haplostephanae. Branchlets 8-10 in a whorl 1.55-2cm long; segments 1-4 all ecorticated. Bract cells 4-6 verticillate. Bracteoles 2-3, exceeding more than oogonium; gametangia sejoined; oogonia 500-700μm long; convolutions 6-10. Oospores golden brown 500μm long.

Habitat: Few plants found in a pool in an agricultural field. pH 7.8; $CaCO^3$ 850 ppm; Qasseem; October, 1986.

Chromosome number: n = 14.

Remarks: This is the only material with completely naked branchlet from this country.

***Chara globularis* Thuill., em. R.D.W.**

Plants monoecious, 20-25cm high, heavily encrusted and brittle. Axes 570μm in diameter; cortex triplostichous, isostichous. Spine-cells solitary rarely properly developed or rudimentary. Stipulodes diplostephanae usually not prominent or only a tier developed. Branchlets 8-9 in a whorl, number of segments 8-9 of which the apical 1-3 segments are ecorticated. Bract cells 5-7, bracteoles 2. Oogonium 800μm long and 580μm wide. Antheridium 400μm in diameter. Oospores orange and visually noticeable to the naked eyes.

Habitat: In an agricultural field about 0.5m deep pool; clear standing water, muddy bottom; pH 7.8; $CaCO_3$ 780 ppm; Al-Hassa, March, 1986. It was also found in Qasseem.

Chromosome number: n = 28.

Remarks: The material corresponds morphologically with the description of Australian material by Wood (1972) and of Japan fig. 63 given by Imahori (1954). The stipulodes are obscure as in var. *globularis*; but in the same plant the apical shoots have both the tiers also developed which reflects the features of var. *leptosperma*. The conflicting characters may have developed because of the local ecological factors.

***Chara setosa* Klein ex Willd.**

Plants monoecious, 5-8cm high, moderately encrustred. Axes 450μm in diameter; cortex triplostichous, isostichous. Spine-cells well developed. Stipulodes in 2 tiers. Branchlets 6-8 in a whorl; segments 5-8, basal segments swollen and its cortex discoloured, remaining segments corticated or some times terminal segments ecorticated. Gametangia conjoined at the basal branchlet nodes. Oogonium 600μm long and 500μm wide. Antheridium 300μm in diameter; oospores 600-630μm long and 400-450μm wide.

Habitat: In a swallow pool, off main drainage ditch; muddy bottom; pH 7.8; $CaCO_3$ 785 ppm; Al-Hassa; March, 1986.

***Chara vulgaris* f. *contraria* (A. Br. ex Kütz., pro parte) R.D.W. (Fig. 4)**

Plants monoecious, varying in length, 15-25cm high, highly encrusted, olive-green. Axes 400-450μm in diameter; cortex diplostichous. Spine-cells solitary, inconspicuous. Stipulodes in two tiers, almost equally developed, short or obtuse. Branchlets 8-10 in a whorl, up to 4cm long; basal segments 4-5 diplostichous or triplostichous, tylacanthous remainder 2-3 apical segments ecorticated. Gametangia conjoined, oogonia 600-700μm long, black or brown with 10-15 convolutions; antheridia 300-350 μm in diameter.

Habitat: In an irrigation canal about 0.5m deep; pH 7.7; $CaCO_3$ 690 ppm; Qasseem; March, 1986.

Remarks: The material is in good agreement with icon number (7) of Wood & Imahori (1964).

***Chara vulgaris* var. *longibracteata* (Kütz. in Reich.) H. et J. Groves (Fig. 5)**

Plants monoecious, 20-30cm high, texture coarse and brittle; odoriferous, heavily to moderately encrusted; gray-green. Axes 600μm in diameter; cortex diplostichous, aulacanthous. Spine-cells rudimentary. Stipulodes diplostephanae. Branchlets 8-10 in a whorl corticated and ecorticated diplostichous but few almost naked branchletsalso exist. Bract cells 8-10 in number, bracteoles 6-8 times longer than oogonium. Gametangia conjoined; oogonium 690μm long; antheridium 440μm in diameter.

Habitat: In a clear water pool about 0.5m deep; pH 7.9; $CaCO_3$ 880 ppm; Al-Hassa; March, 1986. It was also collected from Al-Bahah and Qasseem.

Chromosome number: n = 28.

Remarks: This plant was collected from the main drainage canal at Al-Hassa, covering an area of ca. 0.5 sq.m. Heavy deposition of calcite, which causes the plant to sink under the weight was almost a unit vegetation. Wood & Imahori (1965) reported the occurrence of *C. vulgaris* in a single pool, which may be uniform and could be considered as a unit species. Another collection was also made from the same region where plentiful dessicated plants at a dried pool, presumably changed the soil structure to almost marl, due to the heavy deposition of $CaCO_3$ over the plant body. Good agreement exist between this plant and plates I figure i and VII figure f of the monographs by Corillion & Guerlesquin (1972) and Corillion (1975) respectively.

***Chara zeylanica* var. *diaphana* f. *oerstediana* (A. Br.) R.D.W. (Fig. 6 et 7)**

Plants monoecious, 8cm high, moderately encrusted, rarely lacking calcification. Axes 600-700μm in diameter; cortex regularly triplostichous, isostichous. Spine-cells up to 400μm long, solitary. Stipulodes in 2 tiers, well developed in both rows; upper half longer than the lower ones. Branchlets 8-9 in awhorl 3.5-4cm long, basal segments ecorticated 600-700μm long, branchlets partially corticated, a few totally ecorticated, mostly ultimate 1-2 segments are ecorticated.

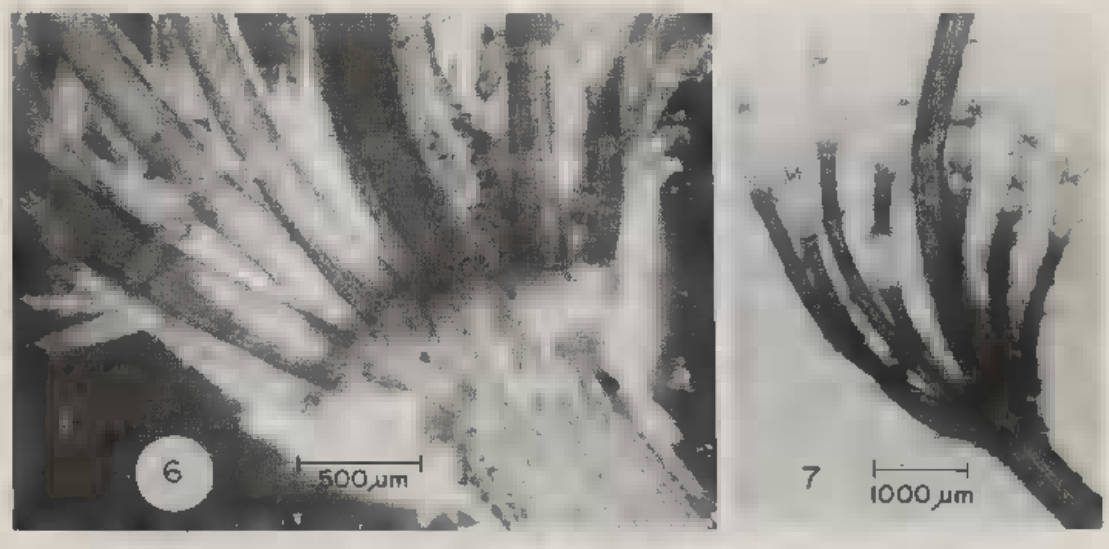

Fig. 6 et 7. *C. zeylanica* var. *diaphana f. oerstediana* (A. Br.) R.D.W., Fig. 6. showing ecorticated gymnopodial basal segments. Fig. 7. whorl of branchlets, showing corticated and ecorticated mixed segments.

Habitat: In an irrigation canal about 0.75m deep, muddy bottom; the plant grows almost as a unit vegetation; pH 7.9; $CaCO_3$ 910 ppm; Al-Hassa; March, 1986.

Remarks: The plants at a glance has a close resemblance in general with the form *depauperata* of icon number (106) of Wood & Imahori (1964), but detailed studies clear the confusions. When spores were inoculated in the laboratory, they grew to robust plant with little calcite deposited, but no fruit bearing plants were achieved. The ecorticated embulged segments of branchlet have broader diameter than the ecorticated segments. This is in good agreement with the form of Wood & Imahori (1964) of Icones (104) and 105). Variation lies with attenuated branchlets, the present material differs in having non attenuated ultimate segments, perhaps as a geographical or regional variation.

***Nitella* sp.**

Plants not fertile, 1.5-3cm high, encrusted. Axes slender 200μm in diameter. Branchlets 5-6 in a whorl, furcate, Dactyls 3-5, end cell conical.

Habitat: In a shallow ditch in an agricultural field; pH 7.9; $CaCO_3$ 755 ppm; Al-Hassa; March, 1986.

Remarks: The plant was very small, encrusted, intermingled and entangled within a collection of chareae. It represented difficulties in identification, fertile plant was not found and records of other collections for comparative study were inadequate to make clarifications. However, the authors resolve the plant upto the genus level.

DISCUSSION

The majority of charophytes were found in Al-Hassa oases, with *Chara vulgaris* f. *contraria*, *C. vulgaris* var. *longibracteata*, *C. globularis* and *C. zeylanica* var. *diaphana* f. *oerstediana* the most abundant species at all sites studied. At certain sites charophytes were found to be dominant vegetation in muddy canals while at other sites they grew in agricultural fields in association with aquatic angiosperms: *Bacopa monnieri* (L.) Pennell, *Veronica anagallisaquatica* L. *Ranunculus aquatilis* L., *Poa annua* L., *Potamogeton trichodes* Cham. et Schecht, *Ceratophyllum demersum* L., *Phragmites australis* Trin. ex Steudel, *Typha domingensis*, (Pers.) Steudel, *Juncus* sp. Most of the taxa found in Al-Hassa occur in Qasseem, suggesting that most likely they share similar water chemistry.The waters of Al-Hassa are highly calcareous with high Mg^{++} : Ca^{++} ratio (mean of 0.38 on a molar basis), calcium rich, Ca^{++} ($\bar{x}$ = 320mg.l^{-1}) and have high HCO_3^- ($\bar{x}$ = 215mg.l^{-1}) see Table I. Carbonate was also recorded in higher values, CO_3^{--} ($\bar{x}$ = 50mg.l^{-1}), in a muddy ditch occupied by chareae and associated with dense masses of *Spirogyra*.

Wood & Imahori (1965) reported that *C. vulgaris* is highly polymorphic plant having varied degree of variations, out of the 22 forms they described two forms: var. *longibracteata* and *f. contraria* are commonly distributed in most parts of Saudi Arabia. There is no obvious indication why the charophyte flora are not widely distributed in the Asir mountains. Previous study of the water chemistry and algal vegetation of the region (Whitton *et al.*, 1986) showed that concentration of soluble reactive phosphate was above the detection limit (0.02mg.l^{-1}) for only one analysis out of nine (table I). Charophyte flora was reported to decline with increase of eutrophication in a lake in Norway, combined with intense growth of *Elodea canadensis* (Langangen, 1974). Perhaps other features of the environment do not favour the distribution of charophytes in the Asir mountains.

Table I - Analysis of Al-Hassa water at two sites, sampled on 20th March, 1986. Concentrations of elements as mg/l, SRP = soluble reactive phosphate.

Ions or Elements	Irrigation canal	Drainage canal
Na^+	338	706
K^+	25	34
Mg^{++}	46	98
Ca^{++}	180	460
CO^{--}_3	-	36
HCO^-_3	120	310
SO^{--}_4	204	418
Cl^-	549	878
$N(NH_3)$	0.10	0.81
$N(NO^-_3)$	0.30	2.8
SRP	0.02	0.06

The genus *Nitella* was found only at one site in Al-Hassa, although it is said to be cosmopolitan in distribution in all temperate and tropical areas (see Wood & Imahori, 1965). Perhaps its distribution is restricted in this country, primary because of the habitat. Most species of *Nitella* seem to occur in pH values 6-7 and soft water, rather than higher pH and hard water (see Wood, 1952).

Acknowledgements

The authors are indebted to Mrs Dr. M. Guerlesquin for supplying some specimens for comparative purposes and for her helpful suggestions and comments. They also wish to thank Dr. H.M. Hassan for identifying the aquatic angiosperms. This research (Bot/1402/19) was supported by the Research Center, College of Science, King Saud University, Riyadh, Saudi Arabia.

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